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Indian Standard

NICKEL CADMIUM BATTERIES FOR ELECTRIC LOCOMOTIVES — SPECIFICATION

UDC 621·355·82 : 629·423

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

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Price Group 4

Secondary Cells and Batteries Sectional Committee, ETD 11

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards after the draft finalized by the Secondary Cells and Batteries Sectional Committee had been approved by the Electrotechnical Division Council.

The special features of a battery operating in electric locomotives namely correct overall dimensions, terminal arrangements ensuring quick interchangeability and ability to withstand temperature between 0°C to 55°C and relative humidity of 100 percent. These batteries should also be capable to withstand vibrations and dust in service when installed in battery boxes suspended from under frame of the locomotives.

Nickel cadmium batteries intended for use in electric locomotives have been covered in this standard.

Nickel cadmium aircraft batteries (aerobatic and non-aerobatic) are covered in IS 13300 : 1992. General requirements and methods of tests for vented type of nickel cadmium batteries are covered by IS 10918 : 1984 'Specification for vented type nickel cadmium batteries'.

In the preparation of this standard, assistance has been derived from:

IEC Pub 623 : 1983 Open nickel-cadmium prismatic rechargeable cells — Part 1: General requirements and test methods issued by the International Electrotechnical Commission (IEC).

IS 7660 : 1988 Lead-acid batteries for electric locomotives and electric multiple units (*first revision*).

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

NICKEL CADMIUM BATTERIES FOR ELECTRIC LOCOMOTIVES — SPECIFICATION

1 SCOPE

1.1 This standard covers methods of tests, performance and other requirements for nickel cadmium batteries used as a source of energy for baby compressor for raising the pentograph and for working the control circuit, normal voltage of which is 110 V.

1.2 It does not however cover batteries for train lighting and airconditioning of railway coaches, requirements of which are under consideration.

2 REFERENCES

2.1 The Indian Standards given below are necessary adjuncts to this standard:

IS No.	*Title*
1885 (Part 8) : 1985	Electrotechnical vocabulary: Part 8 Secondary cells and batteries (*first revision*)
4905 : 1968	Methods for random sampling
8320 : 1982	General requirements and methods of test for lead-acid storage batteries (*first revision*)
9000 (Part 8) : 1981	Basic environmental testing procedures for electronic and electrical items: Part 8 Vibration (sinusoidal) test
10918 : 1984	Vented type nickel cadmium batteries

3 TERMINOLOGY

3.1 For the purpose of this standard, the definitions given in IS 1885 (Part 8) : 1985 in addition to those given in **2.1** to **2.4** of IS 10918 : 1984 shall apply.

4 MATERIALS AND CONSTRUCTION

4.1 Containers Ref Fig. 1

4.1.1 *Battery Container and Lid*

The battery container and lid (whenever provided) shall in general conform to **3.1.1** of IS 10918 : 1984.

4.1.2 *Cell Container*

The cell container shall be of high strength alkali resistant of stainless steel made only.

4.1.3 *Cell Lids*

The cell lids shall be of stainless steel made only.

4.1.4 Each crate shall accommodate six number of Ni — Cd cells. The dimensions and weight of each crate shall not exceed the value given in Table 1.

Table 1

(*Clause* 4.1.4)

Capacity at 5-hour Rate	Overall Dimensions of Crate in mm			Weight with Electrolyte
	Length	Width	Height	
60 Ah	433 + 1	169 + 1	460 + 4	40 kg

4.1.5 *Crate*

The crates shall be of well seasoned hard wood impregnated or coated with a non-hygroscopic alkali proof solution. The cells shall be supported in the crate through suitable insulator as specified below. The design shall be such as to reduce the transmission of track vibration to the cell, insulate it from rest of cells and also provide air space all round and below the cell for adequate ventilation.

4.1.6 *Number of Cells*

There shall be 12 wooden crates of batteries to form one loco set and each crate shall consist of 6 cells. The battery shall be complete in every respect with inter-cell and inter crate connector duly insulated where necessary.

4.2 Terminal Posts and Connections

The terminals shall be provided on each of the cell. The polarity of the terminals shall be clearly distinguished.

4.3 Suspension Insulators

The suspensions insulators shall be of hard synthetic rubber or other suitable materials. They shall be mechanically strong to withstand the weight of the cell under worst conditions of track vibrations. They shall be fit adequately on the bosses provided on the cell container and recesses provided in the crates.

4.4 Separator

The separator used for the cells shall be porous alkali resistant and have insulating capacity to avoid shorting or leakage of the current between the plates of opposite polarity. The separator shall also be dimensionally stable without deformation or deterioration at the temperature of use.

4.5 Electrolyte

The electrolyte used shall be a solution of potassium hydro-oxide in distilled/demineralized water made up to the specified gravity at 27°C as per manufacturer's instructions. Level of electrolyte above top of separator shall not be less than 60 mm.

5 TEST AND PERFORMANCE

5.1 Sequence of Type Tests

a) Checking of dimensions, marking and workmanship,

b) Material and component specification verification test,

c) Air pressure test,

d) Capacity at 10-hour rate,

e) Capacity at 5-hour rate,

f) Retention of charge test,

g) Ampere hour and watt hour efficiency,

h) Endurance test/life test,

j) Storage test,

k) Vibration test, and

m) Insulation resistance test.

5.2 Acceptance Test

5.2.1 *Sampling Scheme and Criteria for Acceptance*

5.2.1.1 *Scale of sampling*

The number of batteries to be selected at random from the lot shall be in accordance with the col 1 and 2 of Table 2.

Table 2 Sample Size and Criteria for Conformity

(*Clause* 5.2.1.1)

Lot Size	Sample Size		C_1	C_2	C_3	Sample Size for Capacity at 5 h Rate
	First Stage	Second Stage				
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Up to 100	8	8	0	2	2	3
101 to 300	13	13	0	2	2	3
301 to 500	20	20	0	3	4	5
501 to 1 000	32	32	1	4	5	8
1 001 and above	50	50	2	5	7	13

In order to ensure the randomness for selection, random number tables shall be used (*see* IS 4905 : 1968).

5.2.1.2 *Criteria for acceptance*

Each of the battery selected in the first stage in accordance with col 1 and 2 of Table 2 shall be subjected to the checking of dimensions, marking and workmanship. A battery shall be declared defective if it fails in any of these requirements. The lot shall be considered as conforming to these requirements if the number of defectives is less than or equal to C_1. The lot shall be considered as not conforming to the requirements if the number of defectives is equal to or greater than C_2. If the number of defectives are in between C_1 and C_2, the second sample as given in col 3 shall be selected from the lot at random and subjected to these tests. If the number of defectives in the two samples combined is less than C_3, the lot shall be considered as conforming to these requirements, otherwise the lot shall be rejected.

The lot which has been found as conforming to the above requirements shall further be tested for capacity at 5-h rate. For this purpose, the sample size is given in col 7 of Table 2. The lot shall be considered as conforming to this requirements if no defective is found in the sample.

The lot shall be considered as conforming to the requirements of acceptance tests if it meets all the requirements of acceptance tests.

6 TEST EQUIPMENTS

6.1 The voltmeter, ammeter, thermometer and hydrometer required for the test specified in this specification shall meet the requirements given in **10.2** of IS 8320 : 1982.

7 INITIAL CHARGE

7.1 This charge is for commissioning the battery for the first time, rate and duration shall be specified by the manufacturer.

8 TEST FOR CAPACITY

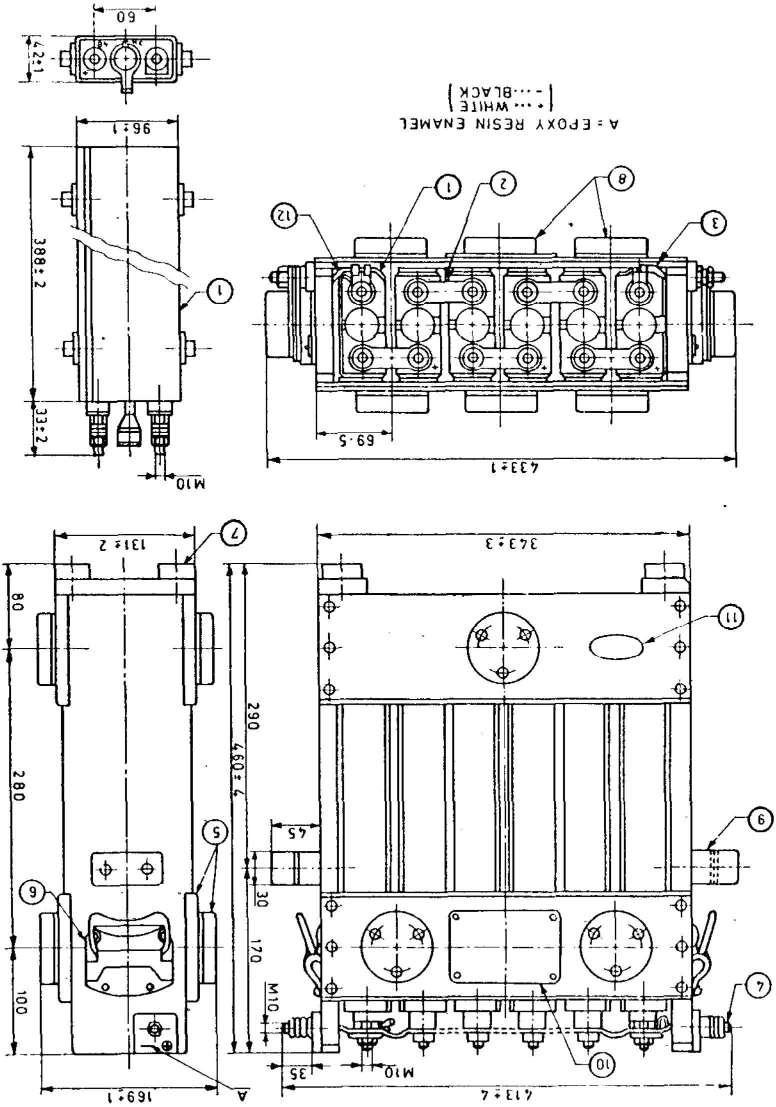
8.1 Charging of Cell

The charge for test purpose shall be carried out at a temperature of 27°C and constant current of $0{\cdot}2\ C_5$, C_5 being the rated capacity. Duration of charge shall be 7 to 8 h. During charging temperature of electrolyte shall be recorded. If the temperature of the electrolyte rises by 10°C above the starting temperature, the cooling shall be employed to limit the temperature rise to 10°C.

8.2 Discharge C_{10}

The discharge shall commence not less than 8 h and not more than 12 h from the completion of full charge and the battery unit shall be discharged through suitable resistance at current $I = 0{\cdot}1 \times C_5$ ampere, C_5 being the rated capacity.

The discharge shall be stopped when the close circuit voltage accross the terminals drop



All dimensions in millimetres.

Sl No.	Description	Per Loco	Matl and Spec.
12	Leading Wire	24	—
11	Number Plate	12	—
10	Name Plate	12	—
9	Shock Proof Rubber	24	—
8	Shock Proof Rubber	72	—
7	Bottom Insulator	48	—
6	Handle	24	—
5	Wooden Battery Tray	12	—
4	Terminal	24	—
3	Terminal Lug	24	—
2	Connecting Bar	60	—
1	Cell	72	—

FIG. 1 ALKALINE BATTERY (OUT-LINE DIAGRAM)

As in the Original Standard, this Page is Intentionally Left Blank to 1·1 × n where n, is the number of cells in series per battery unit.

At this rate of discharge, hourly voltage reading may be taken until the battery unit terminal voltage approached 1·15 V × n volts (n being the number of cell in series per battery unit) after which the reading shall be taken every 25 minutes until the battery terminal voltage falls to 1·1 × n volts.

On the first discharge the battery unit shall not give less than 85 percent of the rated capacity C_5 and rated capacity shall be reached within 3 discharge cycle subsequent to the initial charge.

8.3 Capacity at C_5 Hour Rate

Charge as per **8.1**.

Discharge as per **8.2** however, current will be maintained at $I = 0·2 \times C_5$ and end voltage 1·0 × n.

8.4 Test for Ampere Hours and Watt Hour Efficiency

Ampere hour and watt hour efficiencies when tested shall not be less than 80 percent and 65 percent respectively.

8.4.1 *Ampere Hour Efficiency*

A fully charged battery shall be discharged at $I = 0·2 \times C_5$ ampere to the closed circuit voltage across the battery terminals of 1·0 × n volts, carefully measurement being made of the exact number of ampere hour delivered. On the recharge the same number of ampere hour are put back at the same current. A second discharge shall then be made to the same end voltage as before. The efficiency of battery is then calculated as the ratio of ampere hour delivered during second discharge corrected to 27°C to the ampere hour put in during charge.

8.4.2 *Watt-hour Efficiency*

The watt hour efficiency shall be calculated by multiplying to ampere hour efficiency by the ratio of average discharge and recharge voltages. The value of average discharge and recharge voltages shall be calculated from the log sheet, for Ah efficiency.

8.5 Retention of Charge Test

The charge retention shall be checked by the following tests.

8.5.1 After charging in accordance with **8.1** the cell shall be stored on open circuit for 28 days. The average ambient temperature shall be 27°C, a short time temperature deviation of ±5°C, however, shall be allowed during the storage period. The cell, then, be discharge under the conditions specified in **8.2** and at a rate of 0·2 C_5 A. The loss of capacity shall not be more than 35 percent.

8.6 Endurance Test/Life Cycle Test

8.6.1 The cell/battery shall be given a conditioning cycle as follows:

> The cell/battery shall be charged according to **8.1** and discharged according to **8.2** and the capacity obtaining shall not be less than 95 percent of the rated ampere hour capacity.

8.6.2 *Accelerated Life Cycle*

The life test shall consist of cycles of charging and discharging performed at an accelerated rate.

8.6.2.1 The life cycle test shall be carried out at an ambient temperature of 27 ± 5°C in the manner described in **8.6.3** to **8.6.6**.

8.6.3 On the first cycle the cell/battery shall be charged at a constant current of 0·1 C_5 A for a minimum of 14 h and until there is no further voltage increase for 3 consecutive hourly readings. The cell shall than be discharged at a constant current of 0·2 C_5 A for 2 hours 30 minutes.

8.6.4 On cycles 2 to 24 the cell/battery shall be charged for 3 hours 30 minutes and immediately discharged for 2 hours 30 minutes. The charge and discharge current shall be 0·2 C_5 A. At the twenty fourth cycle after discharge for 2 hours 30 minutes the voltage at the terminals shall still be above 1·0 V per cell. The discharge shall be continued until the value of terminals voltage in any cell is reached up to 1·0 V per cell.

8.6.5 On cycle 25, the cell shall be charged at a constant current of 0·1 C_5 A for a minimum of 14 hours and until there is no further voltage increase for 3 consecutive hourly readings. The cell/battery shall then be discharged at an ambient temperature and at a constant current of 0·2 C_5 A until the voltage at the terminals falls below 1·0 V for any cell.

8.6.6 Cycles 1 to 25 shall be repeated until the ampere hour capacity on any twenty fifth cycle becomes less than 0·6 C_5. The number of cycles obtained with a capacity above 0·6 C_5 Ah shall not be less than 500.

8.7 Insulation Resistance Test

The insulation resistance when measured between the negative terminal and the container based to effect a good electric contact shall not be less than 10 M ohms when measured with a 250 volt dc supply.

8.8 Air Pressure Test

The sealing of each cell of the battery shall be checked by compressed air at a pressure equal to 150 mm H_2O. The volume of the tubes and auxiliary parts in connection with the cell under pressure shall not exceed 0·5 litre. The air pressure in the cell after 15 seconds after the supply has been disconnected shall be noted. The air pressure test shall be carried out in uncharged condition.

8.9 Storage Test

8.9.1 The cell/battery shall be charged according to **8.1** before this test.

The fully charged cell/battery shall be stored at an ambient temperature of 27°C and a relative humidity not exceeding 90 percent for a period of 3 years. After storage for the above period, the cell/batteries shall be discharged according to **8.2** (at a constant current of 0·1 C_{10} A) to an end voltage of 1·0 V per cell after carrying out the instructions of the manufacturer for commissioning back the cell/battery. The Ah capacity of the cell shall then be measured in accordance with **8.2**. The capacity obtained in any one of the first five cycles shall not be less than 0·95 C_5.

One conditioning cycle to the battery may be given during the storage period subject to agreement between the manufacturer and the purchaser.

8.10 Vibration Resistance Test

The test shall be performed in accordance with IS 9000 (Part 8) : 1981, the samples shall be first tested for capacity test as given in **8.5** before putting into vibration test. The test consists in vibrating the batteries at a frequency of 16 Hz with a total displacement of 5 mm for a period of 2 hours, during the vibration, the batteries shall be discharged at the 5 h rate.

8.10.1 *Requirements*

There shall not be any sudden drop either in the current of voltage values and there shall be no spillage of electrolyte during the test.

9 DATA FROM THE MANUFACTURER

9.1 The manufacturers along with the quotation or supply shall provide the information given in Annex A and Annex B.

10 MANUAL OF INSTRUCTION

10.1 The manufacturer shall supply one copy of instruction manual for initial treatment and routine maintenance on service with every batch of 5 sets or part thereof, ordered.

ANNEX A

(*Clause* 9.1)

SCHEDULE OF GENERAL INFORMATION

Sl No.	*Description*	*Particulars to be Filled in*
1.	Maker's name.	
2.	Type of cells.	
3.	Manufacturer's type number.	
4.	Overall dimensions of each cells that is, length × width × height with filler cup open.	
5.	a) Overall dimensions of crate Length × width × height.	
	b) Weight per cell complete with electrolyte.	
	c) Weight of crate with cells and electrolyte.	
6.	Construction of positive plates.	
7.	Construction of negative plates.	
8.	Charge and discharge curves with voltage as ordinates and time as abscissae (100 mm=IV and 38 mm = 1 hour) shall be supplied showing the performance of the cell under the following conditions:	
	a) Discharge of cells at the 10 hours rate.	
	b) Discharge of cells at the 5 hours rate. When plotting above curves a minimum final voltage of 1·10 volt across any cell shall be assumed.	
9.	Electrolyte height above the top of the plates.	
10.	Electrolyte depth below the bottom of the plates.	
11.	a) Quantity of liquid electrolyte per cell.	
	b) Quantity of solid electrolyte per cell.	
12.	Period recommended for renewal of electrolyte.	
13.	Composition of electrolyte.	
14.	Type of electrolyte and supplier's address.	
15.	Specific gravity of electrolyte at 27°C.	

ANNEX B

(*Clause* 9.1)

SCHEDULE OF TECHNICAL DATA

Sl No.	*Description*	*Particulars to be Filled in*
1.	Internal resistance of cell fully charged at 27°C.	
2.	Ampere hour capacity at the 10 hour rate/5 hour rate as the case may be when discharged continuously to a minimum of 1·10 volts across any one cell at an electrolyte temperature of:	
	a) 27°C	
	b) 40°C	
3.	Maximum rate of charge permissible without material damage when cells are in a fully discharged condition.	
4.	Normal charging rate.	
5.	Maximum charging rate.	
6.	Ampere hour efficiency at:	
	a) 10 hours rate.	
	b) 5 hours rate.	
7.	Watt hour efficiency at the:	
	a) 10 hours rate.	
	b) 5 hours rate.	
8.	Rise in electrolyte temperature above the 55°C ambient air temperature when the cells are tested continuously by fully charging at normal rate and dicharging at the 10 hours rate.	
9.	Maximum electrolyte temperature that the cell will withstand without damage:	
	a) Continuously.	
	b) For short period.	
10.	Maximum electrolyte temperature at which the cells will give the following output:	
	a) 100 percent capacity.	
	b) 90 percent capacity.	

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Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi 110002
Telephones : 331 01 31, 331 13 75
Telegrams : Manaksanstha
(Common to all Offices)

Regional Offices :	Telephone
Central : Manak Bhavan, 9 Bahadur Shah Zafar Marg NEW DELHI 110002	331 01 31 331 13 75
Eastern : 1/14 C.I.T. Scheme VII M, V.I.P. Road, Maniktola CALCUTTA 700054	37 86 62
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